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Asamushi, Aomori Prefecture
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青森縣淺虫

BULLETIN OF THE MARINE BIOLOGICAL STATION OF ASAMUSHI,
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DEVELOPMENTAL CYCLE OF *CLADONEMA RADIATUM* VAR. *MAYERI* PERKINS REARED IN THE LABORATORY*

By

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(With one figure and 2 plates)

The medusae of the material used in this investigation are commonly found at Asamushi near where *Sargassum* thrives in summer. We identified our material as *Cladonema radiatum* var. *mayeri* Perkins based on Uchida's (1927) description of the medusa, though some individual differences were observed. We carried out the investigation on the developmental cycle of this variety by the method of rearing from egg to medusa in the Petri dish. Bronne (1897 and 1907), Rees and Russell (1937) and others used special apparatus in rearing the hydroid of certain medusae. The hydroid stage or medusa stage of this variety required no special apparatus for rearing in this investigation.

Before going further we thank Mr. H. Tsujimura of the Biological Laboratory of the Imperial Household for his kind information concerning the kind of food applied in rearing.

MATERIAL AND METHOD

From late June to the end of August in 1956, the medusae of *Cladonema radiatum* var. *mayeri* Perkins were collected by the plankton net from the sea area off the Marine Biological Station at Asamushi where *Sargassum* and other algae are abundant. When the mature medusae were placed in Petri dishes over night, we could find many developing embryos on the bottom of the glass. These medusae caught the young larvae of *Artemia salina*, and liberated many eggs almost every night. The hydroids which developed from the planulae

* Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 227.

could be reared by the young larvae of *Artemia salina*. The sea water of the rearing dishes was renewed every day, and sometimes the surfaces of the bottoms of the dishes were cleaned by a wooden needle carefully. The dishes were placed on the table in summer, but from autumn according to the fall of temperature they were kept in a thermostat at a temperature which was kept at 20–23°C. The investigations of the hydranth, colony and medusa were carried out on the materials which developed from the liberated eggs, and also on a small colony found on the surface of a piece of a stone which was collected from the seashore near the Station, and on two colonies found on two shells of the living *Pecten yessoensis* in an aquarium of the Asamushi Aquarium.

OBSERVATIONS

a) *Development of the egg to the hydroid stage.* The medusae of this variety could be collected by the plankton net during two months from the end of June to that of August in 1956 near the Station. In the early half of this season, it seemed difficult for the medusae to liberate eggs soon after they were collected, and they needed to be reared several days with the larvae of *Artemia salina* until they became mature. In the later half of the season, it was easy to obtain the eggs from the medusae soon after they were collected. When about ten medusae were placed over night in a Petri dish, we could find many embryos in the blastula stage the next morning. These embryos were 0.08 mm in diameter, and had mucous surfaces with which they were attached on the bottom of the glass vessel (Pl. I, b). When the mother medusae in the vessels were removed and the sea water was renewed every day, the embryos developed to the swimming planulae after about two days. The planula is fig-shaped, and measures about 0.09 mm in long axis and about 0.08 mm in short axis. The peripheral zone of the planula is transparent and the inner zone is dark orange in colour (Pl. I, c). They swim by rotating motion along the long axis, and with the dull pole of the planula at the front. The period of the planula stage was not constant in our investigation, but most of them attached to the bottom of the glass vessel within two days and some of them within eight days when the planulae were transferred to another vessel. After about four days of attachment of the planula, we could observe the young hydroid stage. The young hydranth was developed at first as a long process from the attached and flattened planula, then usually a verticil of four long tentacles was formed. But there were many cases in which three tentacles were formed. A hydranth of about eight days old measured about 0.15 mm in length, and about 0.05 mm in width. A tentacle was about 0.07 mm in length (Pl. I, d).

b) *Hydroid stage.* About 20 days after the attachment of the planula, a hydrorhiza was formed as a long stolon in one direction from the root of the

hydranth (Pl. I, e). The second hydranth was formed at the terminal end of the stolon when it reached about 1.2 mm in length (Pl. I, f). After the appearance of the first and the second hydranths, the second stolon, in one type, appeared from the initial hydranth in the opposite direction to the first stolon, then the third hydranth appeared on the distal end of the later stolon. In the other type, the second stolon arises from the second hydranth along the same direction as the first stolon, then the third hydranth forms on its distal end. In general the fundamental linear colony is formed in the above mentioned way

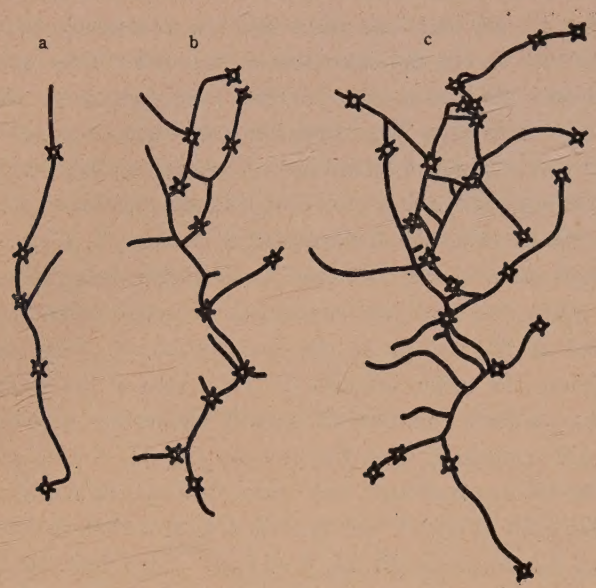

Fig. 1. Formation of a colony of *Cladonema radiatum* var. *mayeri* Perkins. ×10.
a. A new linear colony with five hydranths.
b. Same colony, after 10 days.
c. Same colony, after 13 days.

until four or five hydranths appear (Fig. 1, a). Then the new stolons which are linear or vertical to the initial one were added gradually from each of those hydranths in the early stage, but branches also appeared vertically from the stolons themselves (Fig. 1). According to the elongation of the stolon chains the stolons began to curve irregularly at their distal parts and finally the old colony showed a round outline (Fig. 1, Pl. I, g and h). The stolons grew keeping close contact with the bottom surface of the dish and therefore plane colonies appeared (Pl. I, g). In the colony about two months after the initial hydranth had appeared, new stolons were added also vertically towards the upper direction from the bases of the older hydranths near its central part. In

these old colonies, some hydranths were observed to disappear. On September 20th, the two months old colony was about 3.0–3.5 cm in diameter, and about 160 hydranths were counted in it.

c) *Development of medusa.* On August 18th the first bud of the medusa was found on a hydranth which developed from an egg liberated on July 3rd, or 46 days since liberation of the egg. The hydranth which reached a stage of maturity enabling it to develop the bud of the medusa was about 1.0 mm in height. The bud of the medusa appeared as a small transparent process on a side of the hydranth near the middle part of the column (Pl. I, i). Generally on the hydranth only one bud was observed, but sometimes two buds could be seen, the younger one on the opposite side of the other older one. In a colony which was found on a piece of a stone in 1955, two buds were always observed. About seven to ten days after the appearance of buds, the well differentiated medusae left the column of the hydranth to take to a free swimming life. In the early half of this period, the bud of the medusa developed from a process to a closed sac, the diameter of which was about 0.15 mm (1. I, j). The rudiments of the radial canals were visible as broad and reddish orange lines concentrated toward a point where the bud was connected with the column. The tentacles were differentiated at the margin of the free periphery of the sac (Pl. I, k, Pl. II, l and m). When the differentiation of the organs of the medusa was nearly accomplished, the medusa commenced violent swimming motions although its basal part was still connected with the column (Pl. II, n and o). The medusa just freed from the mother hydranth was about 0.65 mm in height of the bell. and had nine tentacles each of which was provided with a short branch arising from the inner bases of the tentacles (Pl. II, p and q). Each tentacle had five knobs of nematocysts, one on the distal end of the tentacle and the other four arranged almost alternately along the opposite sides of the tentacles. Each short and smooth branch had a knob at its distal end. The radial cansls were very broad, nine in number on the margin of the bell, and as observed in the adult medusa, three pairs among these nine canals gathered into one near the upper center of the bell.

d) *Colonies in rearing.* When a small part of the colony was transferred to another dish, it could be transplanted easily and developed to a new colony. At present about 30 colonies are being reared in the laboratory. Even in the season when liberation of the medusa does not occur in nature, we could obtain them from the reared colonies placed in a thermostat kept at 20–23°C.

REMARKS

We succeeded in rearing colonies of *Cladonema radiatum* var. *mayeri* Perkins by the larvae of *Artemia salina*, and were able to keep many of its colonies in the laboratory. Thus we could observe all stages of the life cycle through a

year. Bronne (1897 and 1907), Rees and Russell (1937) and others used copepods in the plankton as the food in rearing hydroids of certain medusae. We were able to rear the hydroid and medusa by a new food, the young larva of *Artemia salina*, for this variety. These foreign authors used the plunger jar, a continuous current tube or a rocking plate, to supply the fresh water or to make currents in the water in rearing, however, no such special apparatus was needed by us to rear the hydroid or medusa of this variety. The medusa of *Cladonema radiatum* var. *mayeri* Perkins was described by Uchida (1924 and 1927), but the developmental cycle of this variety seems to not have been investigated. In this investigation, the developmental cycle of this variety from the egg to the medusa was observed. Uchida (1927) found the young medusa of this variety at Misaki, and called it the Eelutheria stage of *Cladonema*. According to our investigation, the young medusa which had just left the hydranth resembles Uchida's description and figure, but the radial canal and ring canal of the former is broader than that of the latter. And according to Uchida's description the tentacle has five nematocyst rings but in our observation, the tentacle had five knobs of nematocysts, one on the distal end of the tentacle and the other four arranged almost alternately on the opposite sides and appeared spiral rather than as a ring.

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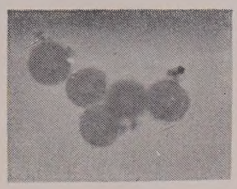
Plate I. Developmental cycle of *Cladonema radiatum* var. *mayeri* Perkins (1).

a. Adult medusa. The bell is about 3 mm in height.
b. Egg in blastula stage. About 0.08 mm in diameter.
c. Swimming planulae. About two days after the eggs were liberated. About 0.09 mm in long axis, and about 0.08 mm in short axis.
d. Young hydroids which developed from attached planulae.
e. Appearance of stolon from base of hydroid. About 20 days after attachment of planula.
f. First colony composed of two hydranths. Stolon is about 1.2 mm in length.
g. Some colonies formed on the bottom of a Petri dish of 9 cm in diameter.
h. Shadow of a typical colony in a Petri dish of 6 cm in diameter. About three months after the initial hydranth appeared.
i. A small and transparent process of a bud of medusa which appeared on a column of hydranth. A hydranth in this stage is about 1.0 mm in height.
j. A sac-like bud of medusa in the middle stage. About 0.15 mm in diameter.
k. A differentiating bud. A hydranth in *k* is that one of which soon after swallowed a larva of *Artemia salina*.

a



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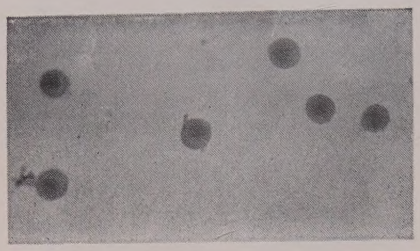

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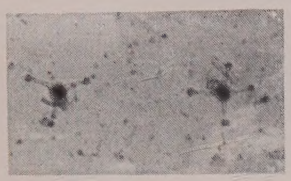

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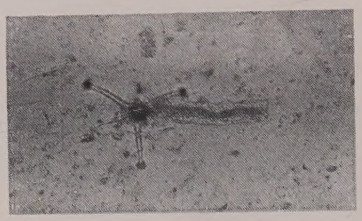

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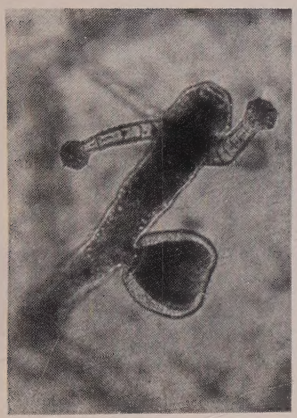

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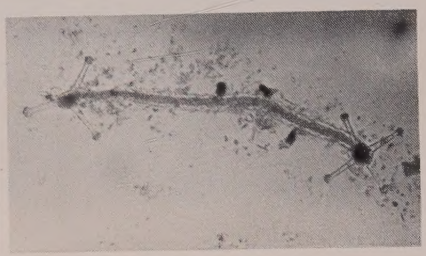

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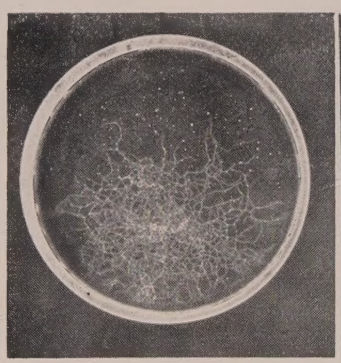

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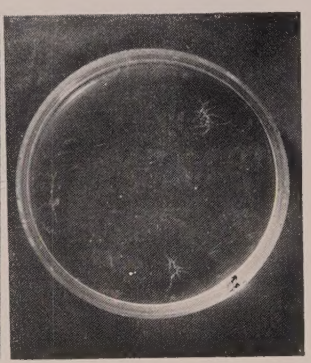

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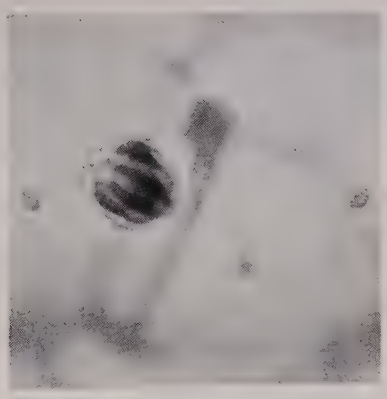
HIRAI, E. and Y. KAKINUMA : Developmental cycle of *Cladonema*

Plate II. Developmental cycle of *Cladonema radiatum* var. *mayeri* Ferkins (2).

l and m. A developing bud of medusa in the later stage. Radial canals, tentacles and other organs are differentiating.

n and o. Medusa bud which has nearly accomplished its differentiation. Medusa in o is making violent swimming motion.

p and q. Young medusa which just escaped from a hydranth. About seven to ten days after the bud appeared. The bell is about 0.65 mm in height, and about 0.85 in width. The tentacle is about 0.65 mm in length.



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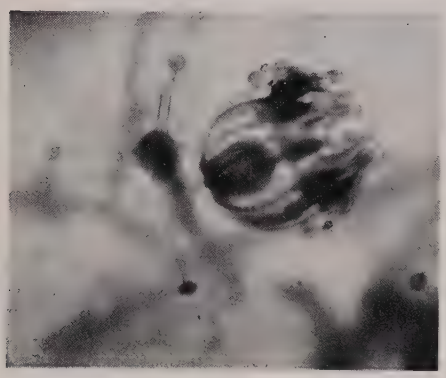

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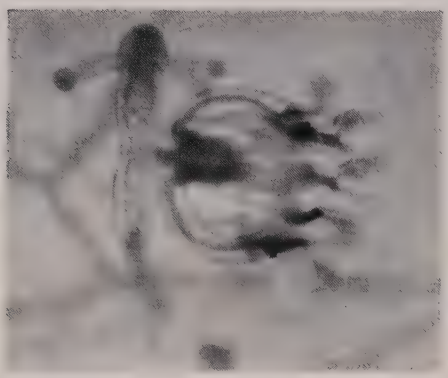

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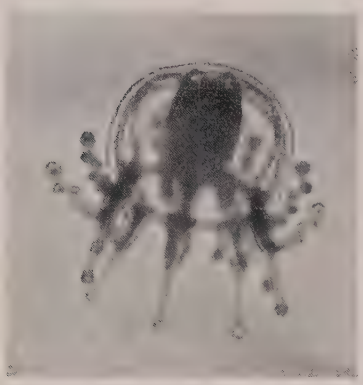

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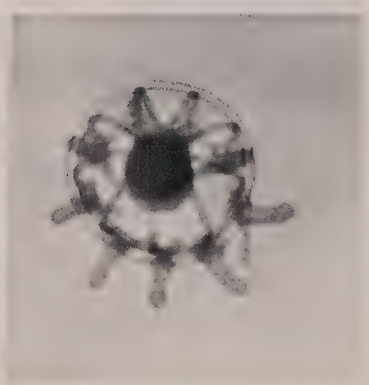

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HIRAI, E. and Y. KAKINUMA : Developmental cycle of *Cladonema*

BULLETIN OF THE MARINE BIOLOGICAL STATION OF ASAMUSHI,
VOL. VIII, NOS. 2, 3 and 4. 1957

STRUCTURE OF THE HYDRANTH OF *CLADONEMA RADIATUM* VAR. *MAYERI* PERKINS AT ASAMUSHI*

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(With one figure)

The medusae of the material used in this investigation are commonly found at Asamushi near where *Sargassum* thrives in summer. We identified our material as *Cladonema radiatum* var. *mayeri* Perkins based on Uchida's (1927) description of the medusa, though some individual differences were observed. In a previous report (1957), we described the developmental cycle of this variety, and in this paper, we shall deal with the special structure of its hydranth.

Before going further we thank Assist. Prof. M. Yamada of the Hokkaido University for his kind information with regard to literatures. We take this opportunity to express our deep gratitude to the Biological Laboratory of the Imperial Household for so kindly providing us with information on an important literature of Perkins.

OBSERVATION

The structures of the hydroid form of *Cladonema radiatum* var. *mayeri* Perkins were observed on the colonies which developed from the eggs in the Petri dishes. The same structures were also observed on the colonies found on the surface of a piece of stone from the seashore and on the two shells of *Pecten yessoensis* in an aquarium of the Asamushi Aquarium. The hydranth is club-shaped, tapering a little from above downward, and has tactile hairs on its surface (Fig.1). The hydranth which is sufficiently mature to develop the bud of medusa is about 1.0 mm in height. The hyrdanth of this variety has only one kind of verticil of

* Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 228.

tentacle, the capitate or distal verticil of the tentacles at the oral end and lacks the proximal or false verticil of the tentacles. The distal verticil of the tentacles is typically composed of four long tentacles, each of which ends in a knob. The nematocysts of the knob are comparatively large. The arm of the tentacle has tactile hairs on its surface. The tentacles are usually four in number disposed in a cross, but in some hydranths there are three, five, six or more in number.

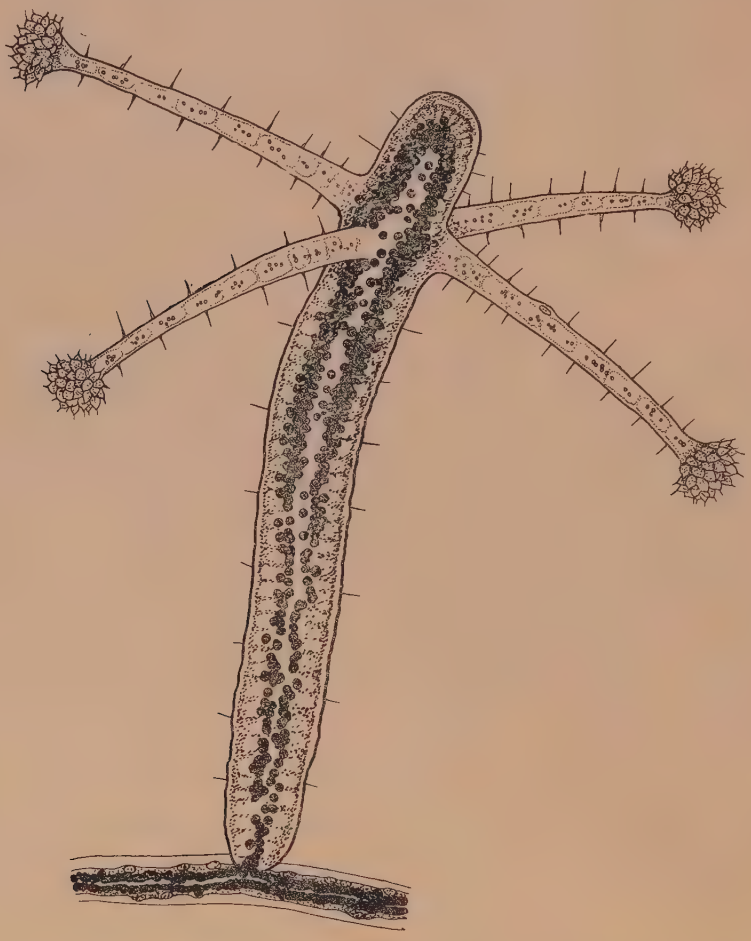

Fig. 1. Hydroid stage of *Cladonema radiatum* var. *mayeri* Perkins. ×150.

We observed a case with twelve tentacles on a hydranth in a transplanted new colony. In these cases with many tentacles, the tentacles other than the four initial ones were observed on the same verticils or on a more distal part from the initial verticil. The hydranth is orange in colour and nearly transparent and the colour of the coenosarc differs according to the food.

REMARKS

According to Allman (1872), the hydranths of *Cladonema* have two verticils of tentacles, each verticil consisting of four tentacles disposed in a cross, – the tentacles of the proximal verticil are filiform and those of the distal verticil are capitate. After Dujardin (1843) observed the life-history of *Cladonema radiatum*, the structure of the hydranth of this species was described by Hincks (1868), Allman (1872) and Mayer (1910). The hydranth of this species as described by Allman has two verticils of tentacles. According to Perkins (1908), the hydranth of *Cladonema mayeri* also has two verticils of tentacles, a capitate set at the oral end, four in number, forming a cross, and a second verticil of four stiff at a distance down the column. Concerning the structure of the medusa, Uchida (1927) stated that *Cladonema radiatum* var. *mayeri* Perkins is referable to *Cladonema mayeri* Perkins from the Bahamas though it differs in colour. According to Uchida (1938), Kramp (1928) described the Japanese medusa as a species distinct from the European one. We observed the structure of the hydranths of *Cladonema radiatum* var. *mayeri* Perkins at Asamushi based on 30 colonies which we reared, and three colonies which were found in the sea and in an aquarium. As the result we could not observe the tentacles of the proximal verticil which are found on the hydranth of *Cladonema mayeri* and other species. The structure of the hydranth of this variety is described for the first time and it may be considered as the most simple type of hydranth of *Cladonema* in so far as we are aware.

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BULLETIN OF THE MARINE BIOLOGICAL STATION OF ASAMUSHI,
VOL. VIII, NOS. 2, 3 and 4. 1957

ON THE BREEDING OF A PERIWINKLE, *LITTORIVAGA BREVICULA* (PHILIPPI)*

By

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(With one figure)

Littorivaga brevicula (Philippi)** is a common periwinkle on the rocky coast in the neighborhood of the Marine Biological Station of Asamushi. Hirase (1927) and Kuroda (1955) described that this species is viviparous and that many juveniles will be found inside the mother shell in the breeding season. However, in the early spring of 1956, the writer found that this species liberates eggs, and thus he found it to be worthy to investigate the breeding of this oviparous species.

Before going further, the writer thanks Dr. Eturô Hirai, Director of the Marine Biological Station of the Tôhoku University at Asamushi, Aomori Prefecture, for his supervision during the course of this investigation. Acknowledgements are due to Dr. Tadashige Habe, Kyôto University, for the identification of this species and information on the breeding of the Littorinidae, and to Dr. Tokubei Kuroda, Kyôto University, for his information on the breeding of this species.

MATERIAL AND METHOD

From February to May in 1956, specimens of *Littorivaga brevicula* (Philippi) were collected from between high to low tide of the rocky coast in the neighborhood of the Marine Biological Station at Asamushi. The materials were cleaned carefully by a brush and five to ten animals were placed in separate glass bottles, each containing 25 cc of normal sea water. After the bottles containing the animals were filled with sea water, liberated eggs were found on their bottoms.

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* Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 299.

** The Japanese name is Tamakibigai.

OBSERVATION

In 1956, the copulating animals were observed from February 15th to the end of April in the shallow waters of the coast, but the greatest number of pairs were observed from the end of February to early April. The temperature of the sea water in February was 5.5°C, and that at the end of April 9.6°C. On February 24th, ten pairs of copulating animals were collected and placed in a bottle, and on March 1st seven eggs with faeces were found on the bottom of the bottle. The animals collected on April 7th liberated many eggs within an hour after being placed in the bottle. The egg was covered by a thin membrane and surrounded by a helmet-shaped, colourless and transparent capsule which was about 350μ in bottom diameter, and about 170μ in thickness (Fig. 1). The bottom surface of the capsule was a little convex. The egg was about 84μ in diameter, and generally one egg was found in each capsule, but some of the capsules contained two to five eggs. At the central part of the capsule bottom, there was a concave spot, through which the young larva was observed to swim out from the capsule.

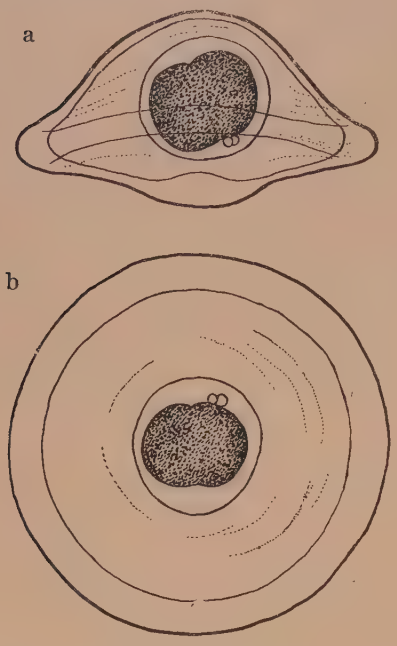

Fig. 1. Egg and its capsule of *Littorivaga brevicula* (Philippi).
a: Viewed from the lateral side.
b: Viewed from the bottom. ×160.

The liberated eggs required about eight days to hatch from the capsules at 10°C. Many young eggs and spermatozoa were found in the gonads of the animals in the season from February to April, but not in May. This fact may suggest that the breeding season of this species at Asamushi is in the early spring of the year, from February to April. The young eggs and the spermatozoa were found in the gonads of animals exceeding 6.5 mm in the shell height.

DISCUSSION

Hirase (1927) and Kuroda (1955) described in "Illustrated Encyclopedia of the Fauna of Japan (Nippon Dôbutsu Zukan)", that Littorina (*Littorivaga brevicula*) (Philippi) is viviparous, but the writer found that it liberates eggs. The capsule of the egg is helmet-shaped. Tokioka and Habe (1953), and Habe (1956) classified the egg capsules of Littorinidae into three groups, and stated that all of the Japanese types of capsules can be included in group 3. But the shape of the egg capsules

of *Littorivaga brevicula* (Philippi) may be included in group 1, helmet-shaped. The capsule of this species resembles that of *Littorina pintado* (Wood) (Ostergaard, 1950) in shape, but has a more conspicuous peripheral brim than that of *Littorina pintado*.

The breeding season of the species of the Littorinidae is as follows : *Littorina saxatilis* (=*L. rudis*) (Lebour, 1937) is throughout the year, L. *littorea* (Moore, 1937) is from November to May, *L. littoralis* (Pelseneer, 1935) is from spring to autumn, and that of *L. neritoides* (Lebour, 1935, Lysaght, 1941) is from September to April. With regard to the breeding season of Littorinidae species in Japan, Abe (1936) observed that the spawning of *Melarhaphe* (*Littorinopsis*) *scabra* (Linnaeus) is in August at Palao, and *Nodilittorina pyramidalis* (Quoy et Gaimard) (=*N. vilis* (Philippi)) and *Peasiella roepstorffiana* Nevill spawn in July and August (Habe, 1955, 1956), *Nodilittorina granularis* (Gray) and *Nodilittorina picta* (Philippi) spawn in July (Habe, 1956), at Shirahama, Wakayama Prefecture. The writer has observed that the spawning of *Nodilittorina granularis* (Gray) is in August at Asamushi. According to the present investigation the breeding season of *Littorivaga brevicula* (Philippi) is from February to April at Asamushi.

SUMMARY

The breeding of *Littorivaga brevicula* (Philippi) was investigated in 1956 at Asamushi.

1. This species liberated helmet-shaped eggs with transparent colourless capsule. The structure of the egg and the capsule is described.

2. The larva hatches about eight days after spawning at 10°C through the concave spot at the center of the bottom of the capsule.

3. The breeding continued from February to April while the animals were still living in the area from high to low tide.

4. Nearly matured eggs and spermatozoa were found in the gonads of the animals exceeding 6.5 mm in shell height.

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TABLE OF OCEANOGRAPHICAL CONDITIONS OBSERVED AT DEFINITE STATION OFF ASAMUSHI DURING 1955*

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(With one table)

The results of oceanographical observations off Asamushi, made by members of the Marine Biological Station of Asamushi, Tôhoku University, will be reported hereafter in table form.

* Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 230.

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